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Dermatoglyphics and Malocclusion-A Forensic Link

Meenu Taneja Bhasin[1], Prashant Bhasin[1], Ashish Singh[2], Nidhi Bhatia[3], Akhilesh H. Shewale[4*] and Natasha Gambhir[5]

[1]Santosh Dental College, Ghaziabad, U.P, India.
[2]Manav Rachna Dental College, Faridabad, Haryana, India.
[3]Department of Periodontology and Oral Implantology, Santosh Dental College, Ghaziabad, U.P, India.
[4]Department of Periodontology, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, Maharashtra, India.
[5]Department of Pedodontics and Preventive Dentistry, Santosh Dental College, Ghaziabad, U.P, India.

Authors' contributions

This work was carried out in collaboration between all authors. Authors MTB and PB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AS, NB, AHS and NG managed the analyses of the study. Author AHS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Dermatoglyphics is known to be one of the best available diagnostic tools in genetic disorders. Dermatoglyphics refers to the study of epidermal ridges on the finger & palmer region 1 of the hand and sole. The finger prints are unique characteristic features of an individual and remain unchanged over lifetime. The dermatoglyphics patterns, have the same origin as that of the facial structures, as well develop concurrently. Thus, hereditary and environmental factors leading to malocclusions may also set off peculiarities in fingerprint patterns. This article aims to give brief insight of different aspects of dermatoglyphics studies highlighting is utility in diagnosing malocclusion and other developmental disturbances of the oro-facial structures.

**Corresponding author: E-mail: Akhileshshewale@gmail.com;*

Keywords: Dermatoglyphics; malocclusion; genetic disorder; finger prints.

1. INTRODUCTION

Dermatoglyphics is the art and science of studying the patterns of fingerprints. It was in 1926 that Cummins & Midlo coined the term Dermatoglyphics. The term derived from a Greek word derma meaning “skin”, glyph meaning “carving” [1]. Cummins is also known as the Father of Dermatoglyphics.

It is well known now that the dermatoglyphic patterns are genetically determined [2]. The epidermal ridges are usually laid down between the tenth and eighteenth weeks of gestation. Once laid down, they remain unchanged except for an increase in size in parallel with general growth (Mulvihill and Smith [3]; Lacroix et al. [4]). Their variable characteristics are not duplicated in other people not even in monozygotic twins [5].

The inheritance of dermal traits is considered to follow a classical polygenic model [6]. Their heridabitilty and polygenic trait have proved useful phenotype to study genetic and heritable disorders, sometimes even superior to stereological markers [7]. Cummins [8] first reported association of specific dermatoglyphic patterns in patients with down syndrome which is a genetic disorder. In recent decades, dermatoglyphics findings have been related to various medical disorders, through several investigations, as a result of which dermatoglyphic analysis has been established as a useful diagnostic and research tool in medicine, providing important insights into the inheritance and embryologic development of many studied clinical disorders [9-11].

In dentistry, the significance of dermatoglyphics has been investigated by several investigators, wherein it, has been used to unveil oral diseases like dental caries, oral cancer, bruxism, anomalies of teeth, cleft lip, cleft palate, periodontal disease, dental fluorosis [12-23].

Malocclusion is genetically controlled and forms one of the most common dental diseases. It is hypothecated that hereditary and environmental factors leading to malocclusions may also set off peculiarities in fingerprint patterns. Hence, the deviation from normal occlusions due to extraneous factors at the time of development, should also reflect in the dermal patterns [24].

To date fewer studies have been done on dermatoglyphics traits associated with malocclusion. Hence the present paper, discusses the role of dermatoglyphics in occlusion.

2. DERMATOGLYPHIC LANDMARKS AND PATTERN CONFIGURATION [2]

2.1 Dermatoglyphic Patterns

The Dermatoglyphics patterns are classified into 3 types, that is: Arches, loops, whorls (Fig. 1).

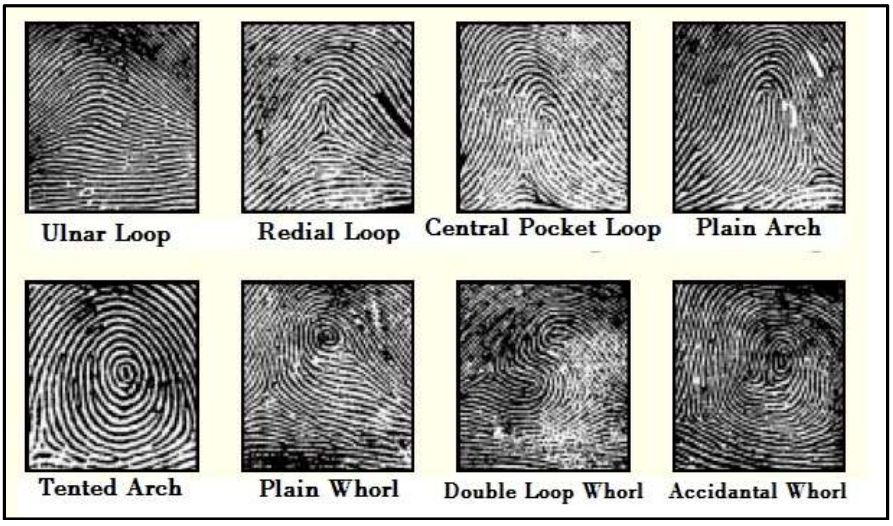

Fig. 1. Fingertip dermatoglyphic patterns

2.1.1 Fingertip patterns

The ridge patterns on the distal phalanges of the fingertips are divided into the three groups.

i) **Arches:** The Arch pattern is made up of ridges lying one above the other in a general arching formation. The arch pattern is subdivided into two types:

   a. Simple or plain arch composed of ridges that cross the fingertip from one side to the other without recurving.
   b. Tented arch composed of ridges that meet at a point so that their smooth sweep is interrupted.

ii) **Loops:** It is the most common pattern with series of ridges entering the pattern area on one side of the digit and leaving the area on the same side.

   The loop pattern is subdivided into two types:

   a. Ulnar loop composed of ridges that open on the ulnar side
   b. Radial loop composed of ridges that open on the radial side.

iii) **Whorls:** It is any ridge configuration with two or more tri-radii. One tri-radius is on radial and the other on the ulnar side of the pattern.

Important landmarks (Fig. 2):

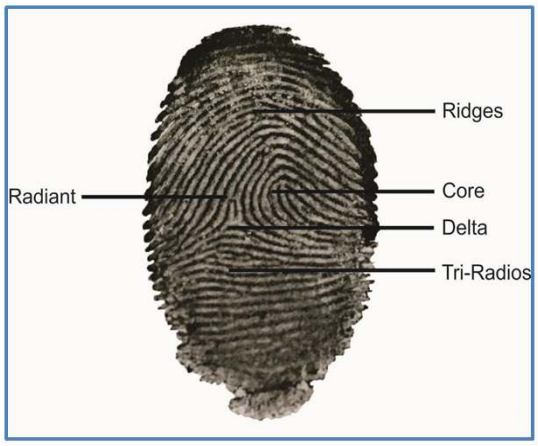

Fig. 2. Important landmarks on fingerprint

i) **Triradius:** Formed by the confluence of three ridge systems that form angles of approximately 120° with one another. The geometric center of the triradius is designated as a triradial point. The triradial point forms one terminus of the line along which ridges are counted.
ii) **Core:** It is in the approximate center of the pattern, of fingerprint pattern. The core may be of different shapes. A) In a loop pattern, the core is usually represented by a straight, rod like ridge or a series of two or more such parallel ridges, over which other recurving ridges pass. If a straight ridge is absent in the center of the loop, the innermost recurving ridge is designated as a core. B) In a whorl, the core can appear as a dot or a short ridge (either straight or bent) or it can be shaped as a circle or an ellipse in the center of the patter
iii) **Radiant:** Which are lines emanating from the tri-radius and enclose the pattern area [25].

2.2 Quantitative Analysis

Many dermatoglyphic characteristics can be described quantitatively, e.g., by counting the number of triradii or ridges within a pattern and measuring distances or angles between specified points.

The following are some often used parameters (Fig. 3):

Pattern intensity: Pattern intensity refers to the complexity of ridge configurations and is expressed, by counting the number of triradius present. According to the number of triradius, a digit can have a pattern intensity 0–3. The simple arch, which lacks a triradius, is assigned the number 0, the tented arch and the loop are both assigned 1, as each has one triradius, and similarly, the pattern intensity of the palm can be expressed as the sum of all triradius present.

Ridge counts: Ridges of the digital areas of the palms are often counted between two digital triradius. The most frequently obtained ridge count is between triradii a and b and is referred to as the a-b ridge count. Counting is carried out along a straight line connecting both triradial points. The count excludes the ridges forming the triradii.

Ridge counting: Ridge counting between the triradius d and t has been proposed as yet another means of describing the position of the axial triradius.

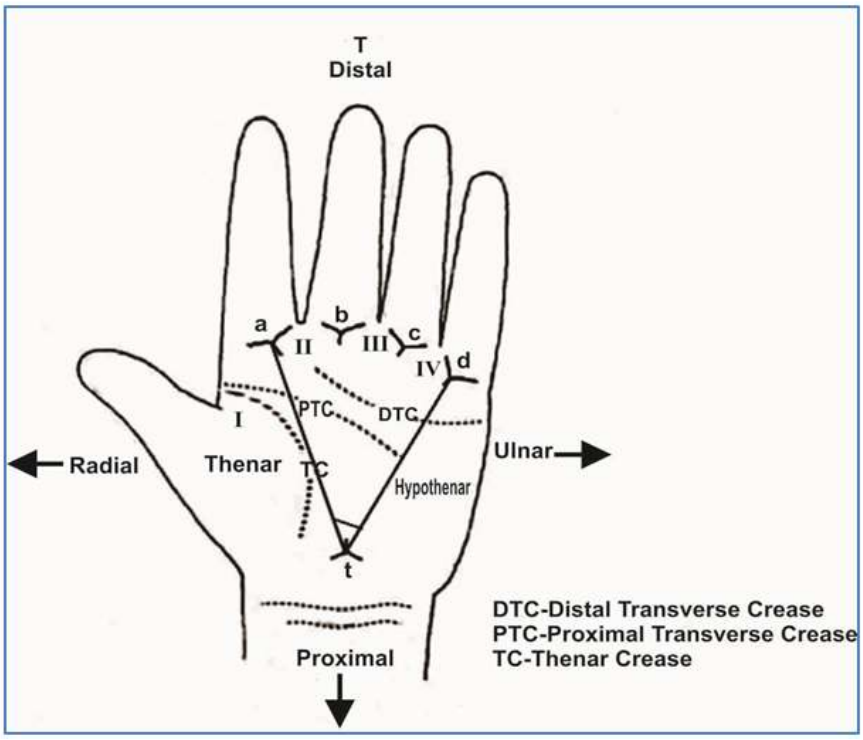

Fig. 3. Landmarks and diagrammatic representation of atd and tab

Atd angle: Perhaps the most widely used method is based on the atd angle. This angle is formed by lines drawn from the digital triradius a to the axial triradius t, and from this triradius t to the digital triradius d. The more distal the position of t, the larger the atd angle.

3. METHODS OF RECORDING DERMATOGLYPICS

3.1 INK Method [1]

The necessary equipment consists of printers ink, a roller, a glass or metal inking slab, a sponge rubber and a good quality paper with a slightly glazed surface.

Advantages:

a. Cheapest of all methods
b. Requires little training
c. Produces instantly visible prints for instant checking

Disadvantages:

a. The Paraphernalia of the ink pad, roller, and printer's ink.
b. Patient feels dirty on application of the black ink and becomes less uncooperative.
c. The ink smudges on researchers hands too.
d. Procedure needs assistant for help

3.2 Inkless Method

Inkless method uses latent-print powder and transparent vinyl adhesive sheets. The "scotch tape india ink" method is another example of an inkless method that incorporates the use of a branded transparent tape, colored chalk and white index cart [26]. A modern and acceptable inkless method for talking finger print is a chemical one, described by Walker [27].

Advantages:

a. The flexibility of the plastic tape allows it to lift surface features not accessible with finger print fluid and paper.
b. Increased speed, clarity & neatness.

Disadvantages:

a. Some subjects may be sensitive to the chemical on the paper

b. Requires training
c. Durability of the print is not yet verified
d. Prior to printing thorough skin cleaning is necessary

3.3 Photographic Method

In the photo paper method, a working solution is prepared, a blotter is moistened with this mixture, which serves as an inking slab. The part which is to be printed is first pressed against the moist blotter for a few second and is then applied against a sheet of photographic paper. The prints are fixed in hypo, washed and dried as in the usual photographic process [28].

Advantage:

a. Materials are easily portable
b. Independent of environmental conditions
c. Good durability, gives best results for dermatoglyphics and creases

Disadvantages:

a. Extensive training required
b. Prints can't be checked instantly
c. Technically difficult

3.4 Integrated Automated Fingerprint Identification System (IAFIS)

Scans fingerprints into a computer database, which transforms it into digital minutiae [29].

4. DERMATOGLYPICS IN DENTISTRY

4.1 Cleft Lip and Palate (CL/P)

Mathew L et al. [12] found increased frequency of ulnar and radial loops than the arches and whorls in cleft lip with or without cleft palate patients compared to controls. Interdigital patterns were less frequent in cleft lip and cleft palate patients. Similarly various other studied also reported a significant dermatoglyphic peculiarities in person with CL/P as compared to those without CL/P [14,15,16].

4.2 Dental Caries

Sharma A and Somani R [16] and Ahmed et al. [17] found highly significant difference in loops between the subject (Caries) and control groups, and also observed significant difference between subject and control groups for microbial growth. Anitha C et al. [18] reported a definite variation in dermatoglyphics between the early childhood caries and caries-free group, indicating that dermatoglyphic patterns can be used as a predictive tool for children with early childhood caries.

4.3 Oral Cancer

Veena HS et al. [19] found a decreased atd angle, increase patterns in Th/I_1 area and increased pattern frequency in I_4 area in OSF patients as compared to normal gutkha chewers. Venkatesh E et al. [20], Gupta A et al. [21] and Ganvir SM et al. [22] in their studies found an increase in frequency of arch and ulnar loop patterns on fingertips in subjects with squamous cell carcinoma.

4.4 Periodontal Diseases

Atasu M et al. [23] conducted a study with the aim of finding a finger-tip pattern type that would identify the patients with periodontal diseases. The results of their study proved that dermatoglyphics could be used together with the other diagnostic methods such as clinical and radiologic investigations and in the identifying of the patients from distinct groups of PD's.

4.5 Bruxism

Increased frequency of whorls and a decrease in frequency of ulnar loops were seen in patients with bruxism than the controls [30].

4.6 Dermatoglyphics Role in Study of Malocclusion

Malocclusion, which may involve misalignment of the teeth, mal-positioning of the jaws, or a combination of both, can create detrimental effects to a person's overall facial esthetics, depending on the severity. Both genetic and environmental factors affect craniofacial development, creating an intricate and elaborate multifactorial etiology for malocclusion. The effect of a particular environmental factors on phenotype varies depending on genetic background, which ultimately determines facial and dental morphology [24].

Table 1. Summary of studies that assessed association of dermatoglyphics with malocclusion

Author	Group	Age	Sample	Sex	Selection Criteria	Parameters recorded	Dermatoglyphic finding
Kharbanda O.P. et al. (1982) [35]	Group 1: Subjects with true mandibular prognathism	NR	25	Males	NR	1. Arches	Craniofacial skeletal class III , associated with
	Group 2:Subjects with class 1 malocclusion					2. Loops	1. Increase in arches and ulnar loops, at the expense of whorls on all digits , except digit 2
						3. Whorls	2. Increased frequency of radial loops
							3. Increase frequency of carpel loops on interdigital area of palms
Reddy S et al. (1997) [36]	Group I (Control): Individuals of class I malocclusion.	12-14 years	96	NR	NR	1. Arches	1. Class II. Div 1- Increased frequency of arches and ulnar loops and decreased frequency of whorls
	Group II– Individuals of class II div 1 & 2 malocclusion					2. Loops	2. Class III: Increased frequency of arches and radial loops with decreased frequency of ulnar loops.
	Group III –Individuals of class III malocclusion					3. Whorls	
Trehan M et al. (2000) [37]	Group I: Normal Occlusion	15- 26 years	60 (15 in each group)	Both	1. Presence of all permanent teeth excluding 3rd molar & in a sufficient state of eruption to allow measurements.	1. Molar Relationship	Normal Occlusion :
	Group II: Bilateral Angels Class I				2. No previous history of orthodontic treatment	2.Overjet	1. As the total ridge count increases, the space discrepancy decreases in maxilla.
	Group III: Class II div I Malocclusion				3. No large coronal restoration that alters tooth coronal shape	3.Overbite	2. As tab angle increase , the cumulative mesiodistal crown width decreases in both maxilla and mandible
	Group IV: Class III malocclusion					4.Height of palatal vault	Class I Malocclusion :
						5. Cumulative mesiodistal crown width	1. As the total finger ridge count increases- the intermolar width decreases in mandible
						6.Intercanine width	2. As the a-b ridge count increases in the right hand, the palatal vault also increases in height
						7. Intermolar width	3. As the atd angle increase rt hand , the arch length decrease in maxilla and as the atd angle increase in left hand the arch length decrease in mandible.

Author	Group	Age	Sample	Sex	Selection Criteria	Parameters recorded	Dermatoglyphic finding
						8. Arch length	Class II div.I Malocclusion:
						9. Arch Perimeter	1. As the total finger ridge count increases the cumulative mesiodistal crown width increases and arch length and arch perimeter decreases in mandible
						10.Space discrepancy	2. As the a-b ridge count increases in the left hand , the intermolar width decreases in both maxilla and mandible
							3. In the left hand , as the tab angle increases, the intermolar width decreases in the mandible and as the atd angle increases the intercanine width also increase in mandible
							Class III Malocclusion:
							1. As the a-b ridge count increases in the right hand , the height of palatal vault also increases and the intermolar width decreases in the mandible .
							2. As the a-b ridge count increases in the left hand , the intercanine width and arch length also increase in mandible
							3. In right hand, as atd angle increase, the intercanine width increase in maxilla and as tab angle increase, the intercanine and intermolar width decrease in maxilla
Tikare S et al. (2010) [38]	Class 1 Malocclusion	12-16 years	696	Both	1. Children with fully erupted permanent 2nd molar	1. Loop	Statistically significant association in the whorl patterns between class 1 and class 2 malocclusions.
	Class II Malocclusion				2. Children with history or those undergoing orthodontic treatment were excluded	2. Whorls	No statistically significant association for the other fingerprint patterns and any classes of malocclusion
	Class III Malocclusion					3. Arches	
Reddy BRM. et al. (2013) [39]	3 Groups , based on angles classification of Occlusion	15-25	Total : 95	Both	Exclusion criteria :	1. Arches	1. Total percentage of patterns :
	Group 1(control group): Subjects with Angles Class I occlusion, with aesthetically pleasing soft tissue profile and acceptable overjet and		30 group in I		1. Patients in whom orthodontic treatment was given earlier or those undergoing orthodontic treatment.	2. Whorls	a) Overall higher frequency for ulnar loops and lowest for central pocket loops

Author	Group	Age	Sample	Sex	Selection Criteria	Parameters recorded	Dermatoglyphic finding
	overbite. ANB angle of 2-3 degrees (angle formed between point “A” on the maxilla and point ‘B’ on the mandible in reference to nasion ‘N’.						
	Group II: Angles Class I malocclusion. ANB angle of 2-3 degree.		30 in group II		2. Patients with syndromic features except malocclusion	3. Loops	b) Higher frequency of twinned loops in class II div 1 and 2 as compared to controls.
	Group III: Angles class II div 1 and div 2 malocclusion ANB angle of more than 3 degrees.		15 in group III		3. Patients with large coronal restorations or prosthesis that can affect the shape and size of crown	4. TFRC	c) Deceased frequency of radial, central pocket and twinned loops in class III malocclusion.
	Group IV: Angles class III malocclusion and ANB angle of more than 2 degree		20 in group IV		4. Patients with a history of trauma or surgical procedures done in the orofacial region	5. Atd angle	2. Total finger ridge count : An average total ridge count for control group was 128 and all other groups showed increase in ridge count , however without any statistical significance .
						6. A-B ridge count	3. Atd angle:
							a) The mean “atd” angle for the control group was 37.95±3.63, 38.15±2.48 for the right and left hand respectively.
							b) Increase mean “atd” angle seen in study group than control group
							4. A-B ridge count : Increase mean A-B ridge counts in study groups as compared to controls .
Rajput S et al. (2014)	Group I: Individuals of class I malocclusion.	Not Mentioned	Total: 24	Not mentioned	Not mentioned	1. Fingertip patterns	1. Whorls pattern: Significantly higher proportion of whorl pattern in Class I as compared to the class II and III.
“Pilot study” [40]	Group II – Individuals of class II malocclusion		Group I: 10 Group II:8			a) Arches	2. Loops: Significantly higher proportion of subjects from class II and III had Loop pattern compared to the class I. Increased proportion loops in class III as compared to class II, but no statistical significance .
	Group III –Individuals of class III malocclusion		Group III: 6			b)Whorls	3. I2/I3/I4 area palmar pattern:
						c) Loops	4. ab count and atd angle :The average of both is not significantly different between three study groups (for both right and left hands).

Author	Group	Age	Sample	Sex	Selection Criteria	Parameters recorded	Dermatoglyphic finding
						2. Palmar patterns: a) Hypothenar area. b) Thenar/First/I1interdigital area. c) I2, I3 and I4 interdigital are 3. Quantitative analysis : a) Total Finger Ridge Count (TFRC). b) ab ridge count. c) atd angle	
Jindal G et al. (2015) [41]	Subjects were divided into 3 groups based on angles classification : Class 1 Malocclusion ' Class II malocclusion	12-16 years	237	Both	1.Children with fully erupted permanent 2nd molar	1. Plain arch	1. Ulnar loop pattern was predominant in all types of malocclusion.
	Class II Malocclusion				2. Children with history or those undergoing orthodontic treatment were excluded	2. Whorl	2. High frequency of plain arches and whorls found in class II and class III malocclusion respectively
						3. Loop 4. FRC 5.Atd angle	3. TRCs higher in class II malocclusion , lower in class III malocclusion 4. No significant correlation between atd angles.

The inheritance of dermal traits follow a polygenic model. Associations of such traits with oral malformations have been studied by Holt SB in 1968 [6]. The epidermal ridges of the fingers and palm and the facial structures originate from the same embryonic tissue: ectoderm. The time of process of development and completion of primary lip and palate and that of dermal ridges are approximately the same, coinciding at 6^{th}-13^{th} week of intrauterine life. The dermal ridge configuration reaches its maximum at around 13 weeks of gestation and is completely established by the 24 weeks of gestation, and once formed, remain constant for lifetime, except in overall size [1-4].

Facial development begins as early as the 4^{th} week of gestation. The palate development begins in 6^{th} week and is completed by the 12^{th} week of gestation [31].

Thus, the face and dermal ridges not only have the same origin but also develop concurrently; the genetic message contained in the genome is deciphered during this period and is also reflected in dermatoglyphic patterns. Thus, any environmental or genetic factors affecting the process of development of dental hard tissues might affect and also get recorded in the dermal ridges. This forms the basis of comparison of malocclusion with that of dermatoglyphics.

The presence of asymmetry between normally symmetric, bilateral traits has been studied using dermatoglyphics patterns [32,33]. Excessive asymmetry between the dermatoglyphic patterns of the left and right hands may signify relatively unstable genetic control during embryogenesis, which in turn, may contribute to the development of malformations [34].

Studies have provided evidence that dermatoglyphic traits are associated with malocclusion. It would be highly valuable from a clinical standpoint if this finding could be substantiated since dermatoglyphic markers could then be used for screening out individuals who might be at an elevated risk of developing malocclusion. However there are few studies conducted in dentistry to establish relationship between finger patterns and malocclusion. Hence the aim was to search for and appraise available studies that pertain to the association between malocclusion and dermatoglyphics.

4.7 Literature Search

The electronic databases of MEDLINE (PubMed), Cochrane, as well Google Scholar were searched for eligible case control studies that assessed dermatoglyphics in malocclusion, published before December 2015. The following terms were used to search for articles “Dermatoglyphics”, “Palm Prints”, “Malocclusion”, “Occlusion”, “and Orthodontics”. After extensive search only 7 studies were found that fit the search criteria. Table 1, discusses the results of various studies on dermatoglyphic and malocclusion.

5. CONCLUSION

Determination of the genetic and environmental origin of malocclusion is important for orthodontic treatment planning and selection of appropriate treatment modalities. Dermatoglyphics can serve as an easy, accessible, inexpensive and non-invasive method of exploring the genetic associations of malocclusion and for timely prevention, however, it cannot be relied upon as the sole factor. This is due to the fact that numerous other factors such as ethnic and racial variations, congenital, environmental and other local factors can also influence the development of malocclusions. Extensive studies of ridge pattern has to be undertaken with several groups according to their racial and ethnic backgrounds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cummins C, Midlo C. Fingerprints, palms and soles- finger prints, palms and soles: An introduction to dermatoglyphics. Philadelphia: Blakinston Company. 1943; 11-15.
2. Galton F. Finger prints. London: Macmillan publishers. 1892;3-5.
3. Mulvihill JJ, Smith DW. The genesis of dermatoglyphics. J Pediatr. 1969;75: 579–89.
4. Lacroix B, Wolff-Quenot MJ, Haffen K. Early human hand morphology: An estimation of fetal age. Early Human Development. 1984;9:127–36.
5. Penrose LS, Ohara PT. The development of the epidermal ridges. J Med Genet. 1973;10:201-8.
6. Holt SB. The hypothenar radial arch, a genetically determined epidermal ridge configuration. Am J Phys Anthropol. 1975; 42:211-4.

7. Uchida JA, Solton HC. Evaluation of dermatoglyphics in medical genetics. Pediatr Clin North Am. 1963;10:409-22.
8. Cummins H. Dermatoglyphics stigmata in mongoloid imbeciles. Anat. Rec. 1939;73: 407-15.
9. Schaumann B, Alter M. Dermatoglyphics in medical disorder. Springer Verlag New York Inc; 1976.
10. Ellor CS. Dermatoglyphics in schizophrenia. I. Qualitative aspects. Br J Psychiatry. 1968;114(516):1387-97.
11. Miller JR, Giroux J. Dermatoglyphics in paediatric Practise. J. Pediatr. 1969;75: 302-312.
12. Mathew L, Hegde AM, Rai K. Dermatoglyphic peculiarities in children with oral clefts. J Indian Soc Pedod Prev Dent. 2005;23(4):179-82.
13. Maheshwari N, Bansal K, Rao DJ, Chopra R. Comparison of dermatoglyphic traits and dental anomalies associated with cleft lip or cleft lip and palate patients with normal healthy children. J Indian Soc Pedod Prev Dent. 2013;31(4):260-4.
14. Scott NM, Weinberg SM, Neiswanger K, Brandon CA, Daack-Hirsch S, Murray JC, et al. Dermatoglyphics fingerprint heterogeneity among individuals with nonsyndromic cleft lip with or without cleft palate and their unaffected relatives in China and the Philippines. Hum Biol. 2005; 77(2):257-66.
15. Kanematsu N, Yoshida Y, Kishi N, Kawata K, Kaku M, Maeda K, et al. Study on abnormalities in the appearance of finger and palm prints in children with cleft lip, alveolus and palate. J Maxillofacial Surg. 1986;14:74-82.
16. Sharma A, Somani R. Dermatoglyphic interpretation of dental caries and its correlation to salivary bacteria interactions: An *in vivo* study. J Indian Soc Pedod Prev Dent. 2009;27:17-21.
17. Ahmed RH, Mohammed I. Aref, Rania M. Hassan, Noura R. Mohammed. Dermatoglyphic study on patients with dental caries restored with dental fillings and its correlation to apoptosis induced by dental fillings. Nat Sci. 2010;854-57.
18. Anitha C, Konde, Raj NS, Kumar NC, Peethamber P. Dermatoglyphics: A genetic marker of early childhood caries. J Indian Soc Pedod Prev Dent. 2014;32(3): 220-4.
19. Veena HS, Humbarwadi RS, Potturi BR. Cross-sectional study of palmar dermatoglyphics among gutkha chewers with and without oral sub mucous fibrosis. Karnataka, Bengluru: Rajiv Gandhi University of Health Science; 2006. (MDS Thesis)
20. Venkatesh E, Bagewadi A, Keluskar V, Shetti A. Palmar dermatoglyphics in oral leukoplakia & oral squamous cell carcinoma patients. Indian acad Oral Med Radiol. 2008;20:94-99.
21. Ambika G, Freny RK. Role of dermatoglyphics as an indicator of precancerous and cancerous lesions of the oral cavity. Contemp Clin Dent. 2013; 4(4):448–53.
22. Ganvir SM, Gajbhiye NY. Detection of genetic predisposition in Oral Squamous Cell Carcinoma (OSCC) and oral submucous fibrosis patients by qualitative analysis of finger and palm-print patterns: A dermatoglyphic study. Clin Cancer Investig J. 2014;3:377-82.
23. Atasu M, Kuru B, Firatli E, Meric H. Dermatoglyphic findings in periodontal diseases. Int. J Anthropol. 2005;20:63-75.
24. Mossey PA. The heritability of malocclusion: Part 2. The influence of genetics in malocclusion. Br. J. Orthod. 1999;26(3):195-203.
25. Durham NM, Plato CO. editors. Trends in Dermatoglyphic research. Springer. 1960; 50-51.
26. Cotterman CW. A scotch tape india ink method for recording Dermatoglyphics. A J Hum Genet. 1951;3(4):376-79.
27. Walker NF. Inkless method of finger, palm and sole printing. J Pediat. 1957;50(1): 27-29.
28. Arthur AM. A new method for taking fingerprints using photographic film. 1972; 36(3):441-2.
29. Integrated automated finger print Identification system (IAFIS).
    Available: www.fbi.gov/hq/cjisd/iafls.htm
30. Polat MH, Azak A, Evlioglu G,Malkondu OK, Atasu M. The relation of bruxism and dermatoglyphics. J Clin Pediatr Dent. 2000;24:191-4.
31. Ferguson MW. Palate development. Development. 1988;103(Suppl):41-60.
32. Palmer AR, Strobeck C. Fluctuating asymmetry: Measurement, analysis, patterns, Annu. Rev. Ecol. Syst. 1986;17: 391-421.

33. Parsons PA. Fluctuating assytemry: A biological monitor of environmental and stress. Hereditary. 1992;68:361-4.
34. Naugler CT, Ludman MD. A case- control study of fluctuating dermatoglyphic asymmetry as a risk marker for developmental delay. Am. J. Med Genet. 1996;66:11-14.
35. Kharbanda OP, Sharma VP, Gupta DS. Dermatoglyphic evaluation of mandibular prognathism. J Ind. Dent. Assoc. 1982; 54:179–86.
36. Reddy S, Prabhakr AR, Reddy VVS. A dermatoglyphic predictive and comparative study of class I, class II, division 1, division 2 and class III malocclusions. J Indian. Soc. Pedo. Prev. Dent. 1997;15(1):13–19.
37. Trehan M, Kapoor DN, Tandon P, Sharma VP. Dermatoglyphic study of normal occlusion and malocclusion. J. Ind. Orthod. Soc. 2000;33:11–16.
38. Tikare S, Rajesh G, Prasad KVV, Thippeswamy V, Javali SB. Dermato-glyphics- A marker for malocclusion? Int J Dent. 2010;60:300-4.
39. Reddy BRM, Sankar SG, Roy ET, Govulla S. A comparative study of dermatoglyphics in individuals with normal occlusions and malocclusions. J Clin Diagn Res. 2013; 7(12): 3060–65.
40. Rajput S, Shenoy S, Thoke B. Palmar dermatoglyphics versus malocclusion: A pilot study. IJRID. 2014;4(6):48-56.
41. Jindal G, Pandey KR, Gupta S, Sandhu M. A comparative evaluation of dermatoglyphics in different classes of malocclusion. The Saudi Dental Journal. 2015;27:88-92.

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